

THE SECULAR VARIATION OF THE MAGNETIC ELEMENTS
IN SOUTH AFRICA DURING THE PERIOD 1900-1913.

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The study of the secular variation of the magnetic elements in South Africa is of more than usual interest because of the abnormal values of the changes. In the magnetic charts of the world published by the British and by the United States naval authorities, the one in 1905 the other in 1907, the annual change off certain parts of the East African coast is given as 10' decrease of westerly declination, a result greater in absolute value than in any other region except off the east coast of South America. It has been possible and necessary in the course of a magnetic survey of South Africa to determine the secular variation not only of the declination but of the horizontal intensity and of the dip over the mainland, for approximately the same epoch as that for which the naval charts were issued, and thus to see to what extent the abnormal values exist on the mainland in South Africa.

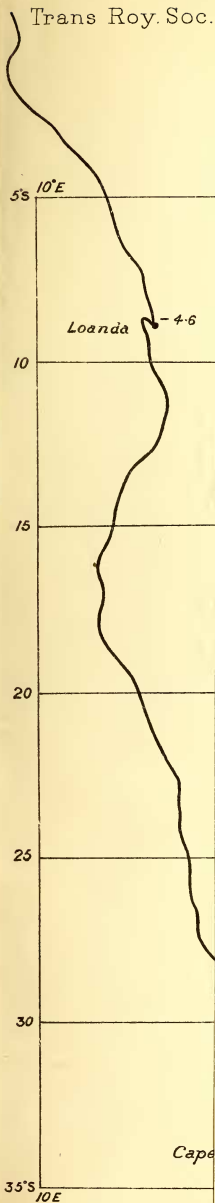
The period over which the observations extend is from 1898 to 1913, the greater number however belongs to the period 1903 to 1913; the actual results, except for the stations given at the end of this paper, have already been published from time to time. The method of observing and the reductions applied have also been explained in an earlier publication.

In addition to results obtained with the same instruments in Africa south of the Zambesia, observations for a few other stations have been embodied in so far as such were available for places south of the equator. The extra stations thereby included are Loanda, Mozambique, Dar-es-Salam, Tananarive, Mauritius, and Delagoa Bay. In the first set of stations care was taken to make the observations at any one station at the same time of day, in this way obviating the necessity for the application of any correction for daily variation, a quantity which is not known accurately on the South African mainland.

The values of the magnetic elements are given in the list which follows ; further details of the observations at these stations, the position of the stations, the instruments used, and other facts will be found in one or other of the following publications. The number given immediately after the name of the station in Appendix I. refers to these publications.

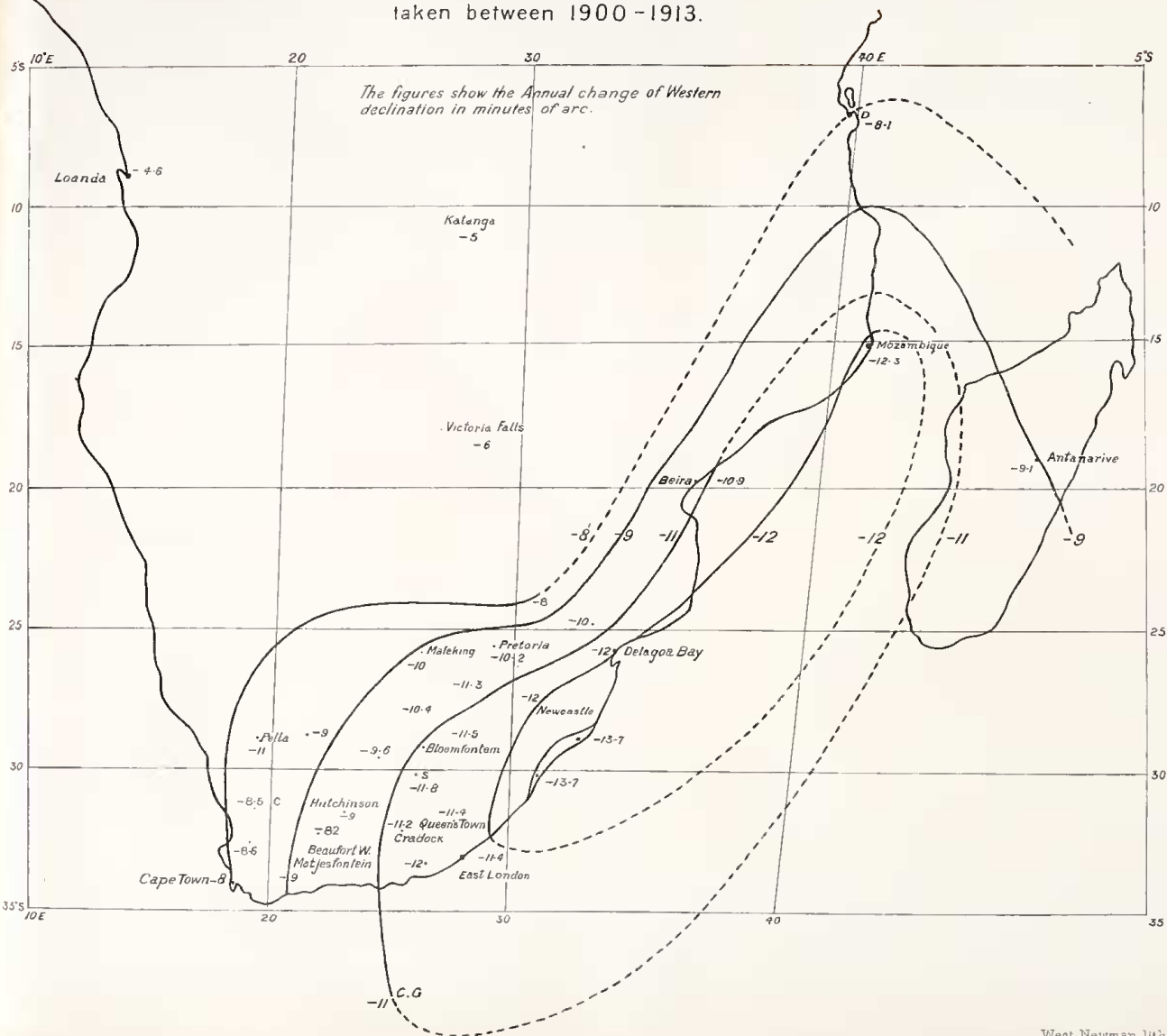
1. "The Magnetic Elements at the Cape of Good Hope from 1605 to 1900." By J. C. Beattie and J. T. Morrison. Trans. S.A. Philosophical Society, vol. xiv., p. 1. Cape Town, 1903.
2. "Report of a Magnetic Survey of South Africa." By J. C. Beattie. Royal Society. London, 1909.
3. "On Magnetic Work in Southern and Central Africa." By J. C. Beattie and J. T. Morrison. Washington, 1913.
4. "Further Magnetic Observations in South Africa." By J. C. Beattie. Trans. Royal Society of South Africa, vol. iv., p. 9. Cape Town, 1914.
5. "Bulletin de l'institut océanographique. Contribution aux études de magnétisme terrestre en Afrique." Par F. A. Chaves. Monaco, 1908.
6. "Report on the Results of a Magnetic Survey of the Clanwilliam, Van Rhynsdorp, and Calvinia Districts." By J. C. Beattie. Report of the South African Association for the Advancement of Science. Cape Town, 1909.
7. Appendix to present paper.
8. "Veröffentlichungen des hydrographischen Amtes der K. und K. Kriegs-Marine in Pola." Gruppe IV. Erdmagnetische Reisebeobachtungen III Heft. Pola, 1902.
9. "Magnetic Observations in Northern Africa." By B. F. E. Keeling. Cairo, 1907.

The results for the declination are shown in Plate I., where the lines of equal annual change have been drawn. The only results not given in the preceding list are, first, the secular change determined from the Gauss-Carnegie observations ("Terrestrial Magnetism," vol. xvi., p. 136), and secondly, the change given for the Katanga district of the Congo, a result determined from a comparison of Beattie and Morrison's observations in Northern Rhodesia in 1909 and Lemaire's in the Congo in 1899 and 1900. It will be noticed that the lines of annual change have been closed so as to show a centre of high annual decrease on the east coast of the mainland and extending into the neighbouring ocean ; the only justification for the latter is the analogy with the results shown on the British and American magnetic charts. A comparison of the map for the mainland given here with the charts shows no continuity between the land and the sea curves, nor does the extraordinarily high value over the land find any analogue on the sea except in the case of the result obtained from the



Secular variation of the
Magnetic declination
in SOUTH AFRICA from observations
taken between 1900 - 1913.

*The figures show the Annual change of Western
declination in minutes of arc.*



Gauss-Carnegie observations. The annual changes recorded in this paper vary from an average decrease of 1'·5 of westerly declination at Mauritius during the period 1900–1909, a change which was turned into an increase of 1'·4 per year of westerly declination between 1907 and 1909, to an annual decrease of about 14' in the neighbourhood of Durban. If we go in a north-westerly direction from the latter place the annual decrease becomes less, and falls to 5' at Loanda. The decrease in the absolute value of the change is quite definite, though not so great as we go west or indeed in any direction other than seaward from this centre of greatest change.

A further interesting conclusion which can be drawn from the table is that at the present day the absolute value of the change is increasing at all stations; the lines of equal annual change appear to be moving inland in an approximately westerly direction. This will be evident from

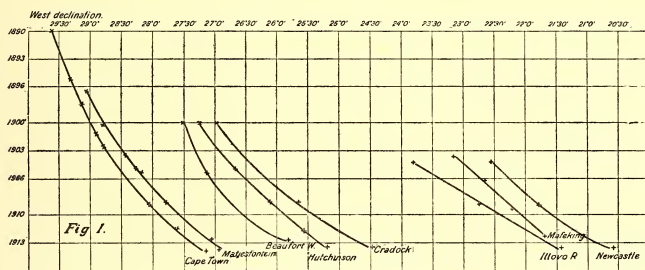


FIG. 1.

the consideration of the results at the following places: At Beaufort West the mean decrease between 1900 and 1912 is 8'·2 per year, between 1905 and 1912 it is 10'·8; at Cape Town between 1901 and 1914 the mean decrease is 8'·1, between 1909 and 1914 it is 9'·7; at Cradock the mean change between 1900 and 1913 is 11'·2, between 1908 and 1913 it is 13'·8; at Hutchinson the mean change between 1900 and 1913 is 9'·3, between 1908 and 1913 it is 11'·0; at Illovo River between 1903 and 1913 it is 14'·6, between 1908 and 1913 it is 15'·6; Matjesfontein has a mean change between 1900 and 1913 of 8'·9, and 11'·0 between 1908 and 1913; Newcastle has a mean change of 9'·4 between 1903 and 1913, which increases to 14'·6 between 1908 and 1913.

In Fig. 1 the change in declination is shown for the whole period at a number of places.

The results for the dip are shown in Plate II. The greatest annual

change is found in the south-western part of the continent; in the neighbourhood of Cape Town it amounts to an increase of southerly dip of 8' per year; the annual increase becomes less towards the east, and off the coast of Natal is between 4' and 5' per year; the line of no change passes through Madagascar, and east of that the change is a decrease of southerly dip. Lines of equal annual change have been drawn.

In Fig. 2 the change in dip is shown for the whole period at a number of places.

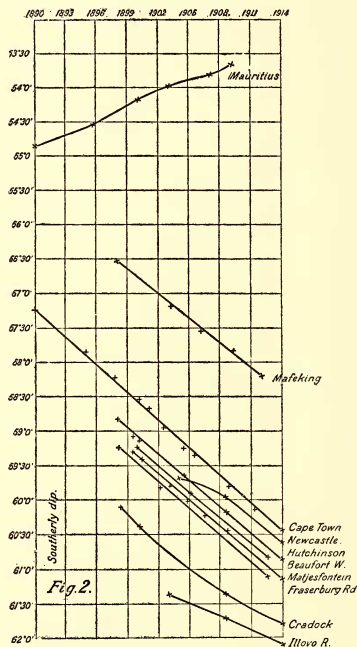
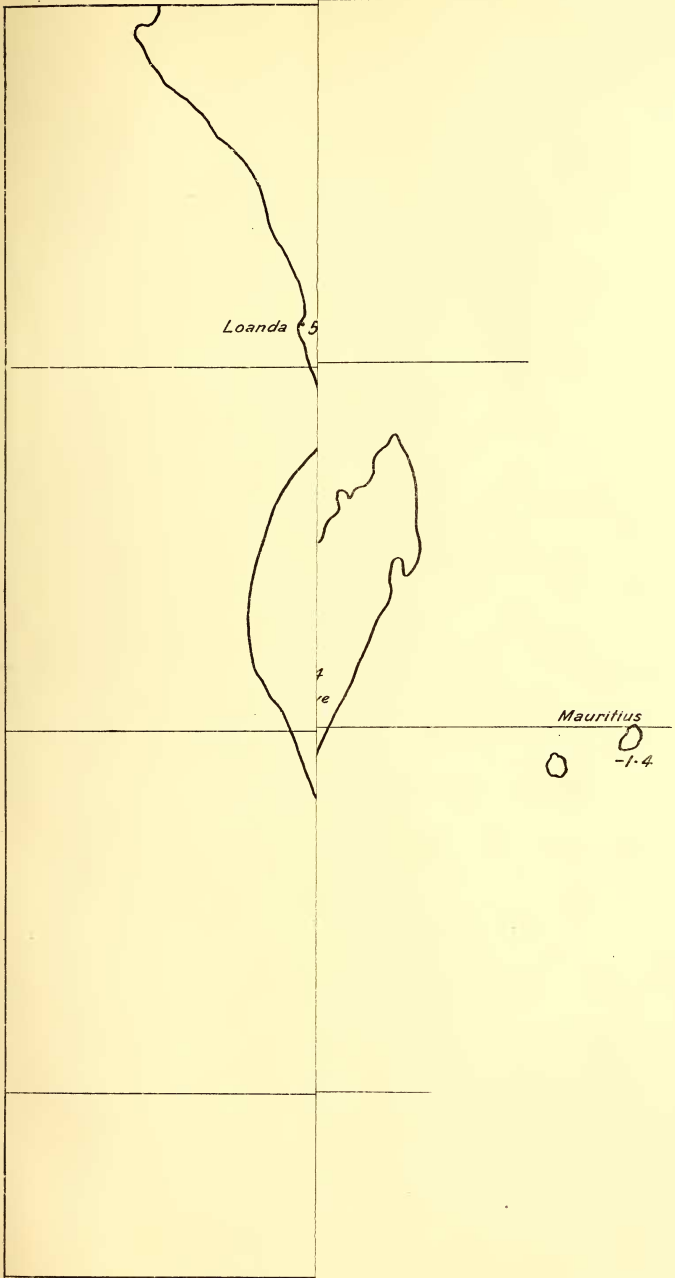


FIG. 2.

The annual change in the horizontal intensity at various places is shown in Plate III. No attempt has been made to draw the lines of equal annual change. Generally it may be stated that the decrease amounts to approximately 90 γ over the southern part of the continent, and that a pronounced decrease in this value is shown towards the north in Rhodesia.



Loanda 5

re

Mauritius

-1.4

Secular Variation of the
Dip
in SOUTH AFRICA derived from
observations taken between
1900-1913.
*The figures show the Annual Increase of
Southerly dip in minutes of arc.*

Loanda 5.0

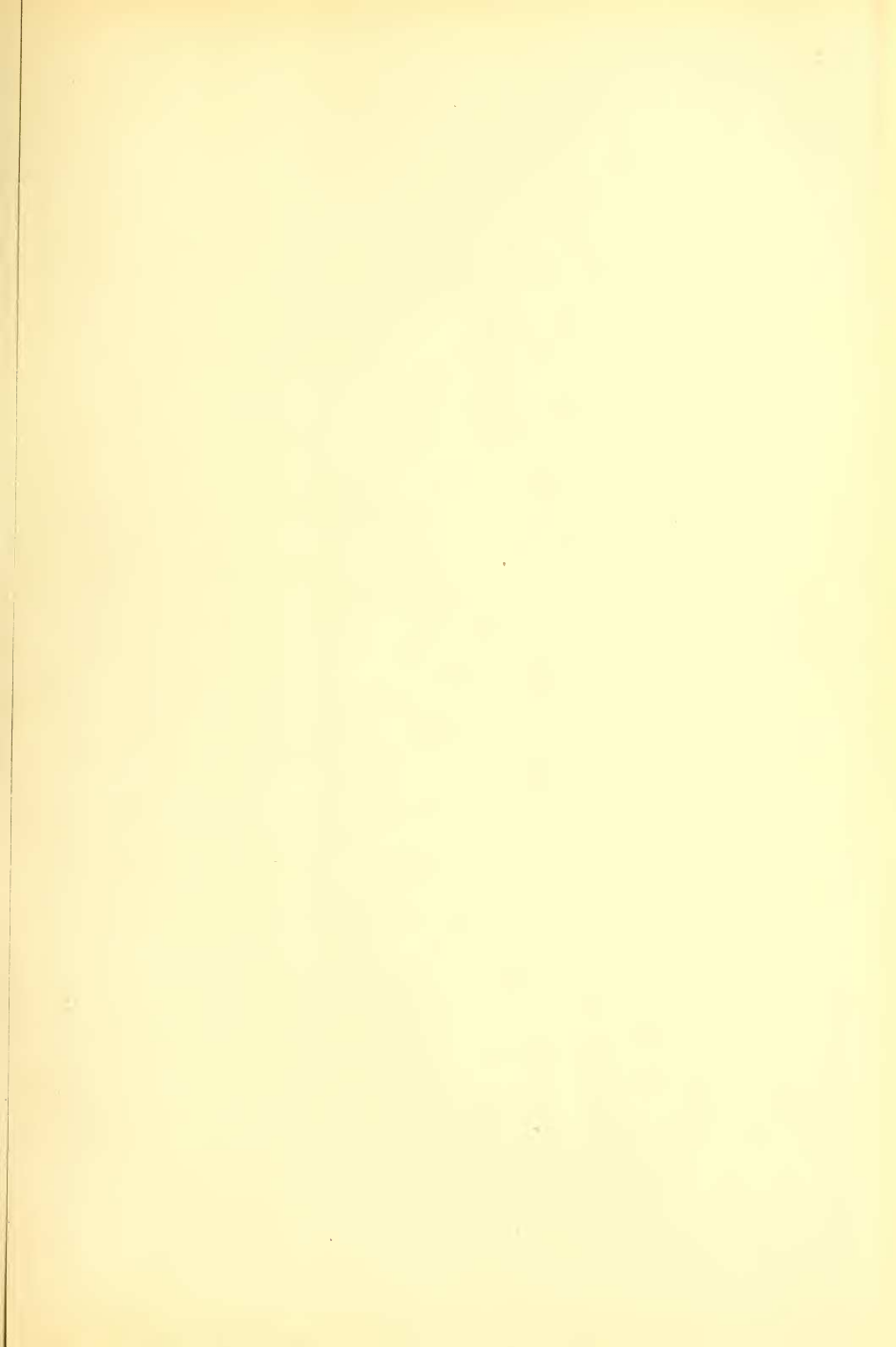
Dar-es-Salam 2.1

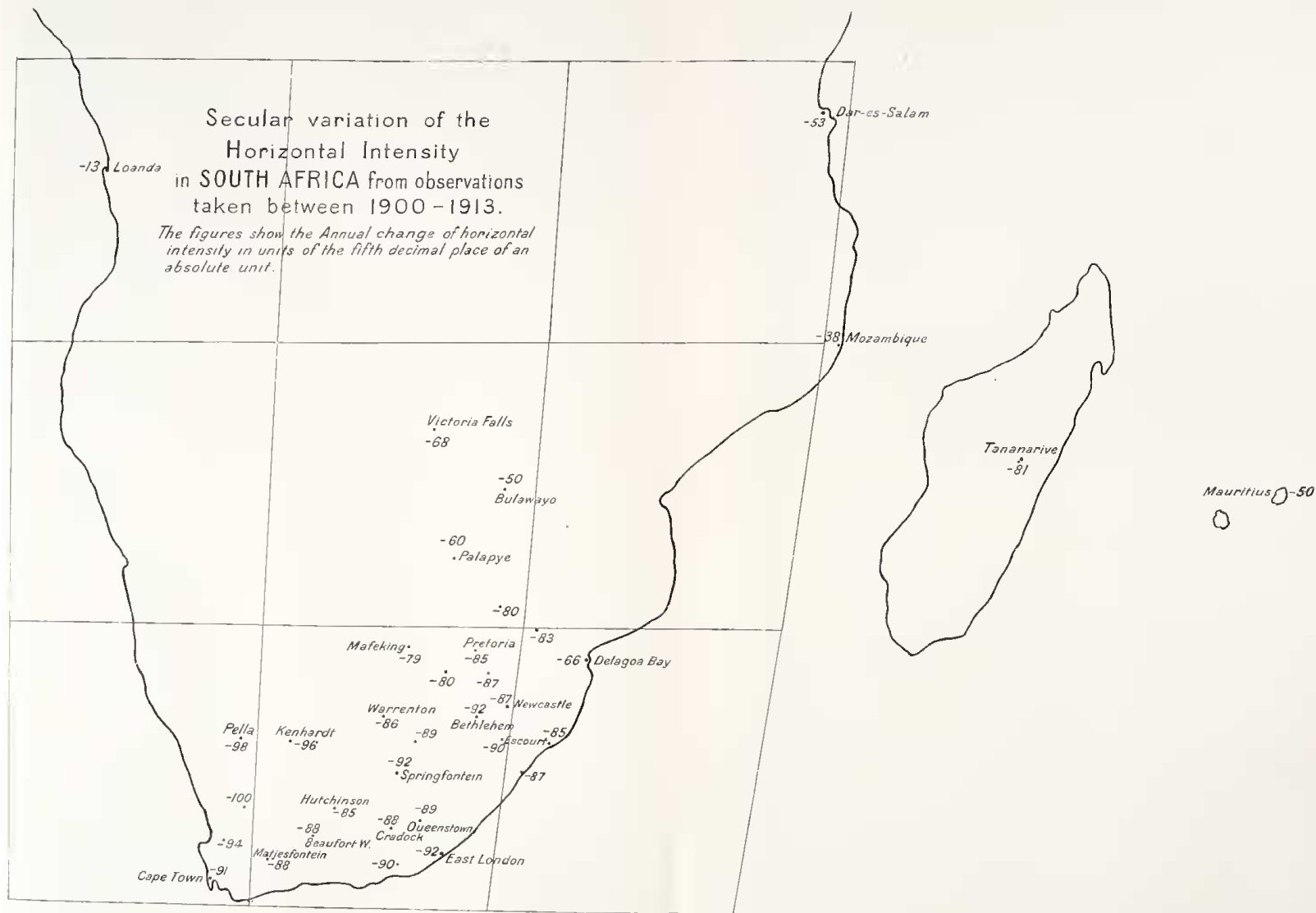
Mozambique 1.8

5.5 Victoria Falls

-0.4
TananariveMauritius
-1.4

6.1 Bulawayo
6.1
5.1
4.1
6.5 Palapye
6.4
5.4
4.9
4.4
Mafeking 7.1
Pretoria 5.8
6.8
4.5
Newcastle 5.8
Estcourt 4.8
5.5
4.7
Warrenton 6.8
6.3
Springfontein 6.7
5.4
Queenstown 6.6
Cradock 5.6
East London
Calvinia 7.9
Hutchinson 7.5
7.1
Beaufort W. 7.6
Matjesfontein 7.7
Cape Town 7.0





APPENDIX I.

LIST OF REPEAT STATIONS WITH RESULTS OF OBSERVATIONS.

Alicedale Junction. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1910·95	25° 45'·9 W.	62° 18'·7 S.	·16900
1900·06	28 00·2	61 08·8	·17858

Secular Variation.

1910·95–1900·06 = 10·89 yrs.	–12'·3	+6'·4	–88 γ
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Beaufort W. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1912·50	25° 48'·4 W.	60° 48'·7 S.	·17371
1905·04	27 08·4	59 55·7	·18070
1900·02	27 30·9	59 14·0	·18507
1899·54		59 14·6	·18504

Secular Variation.

1912·50–1905·04 = 7·46 yrs.	–10'·8	+7'·1	–94 γ
1905·04–1900·02 = 5·02 yrs.	–4·5	+8·0	–84 γ
1912·50–1900·02 = 12·48 yrs.	–8·2	+7·6	–91 γ

Biesjespoort. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1912·51	24° 45'·6 W.		·17688
1904·08	23 31·7	59° 21'·2 S.	·18888

Secular Variation.

1912·51–1904·08 = 8·43 yrs.	–8'·7		–139 γ
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Bulawayo. (2, 3)

Date.	Declination.	Dip.	Horizontal Intensity.
1909-29	17° 11'·7 W.	54° 04'·5 S.	·21186
1904-59	18 27·1	53 35·6	·21389
1898-04		52 49·5	·21798

Secular Variation.

1909-29-1904-59 = 4·70 yrs.	- 15'·8 (?)	+ 5'·8	- 43 γ
1904-54-1898-04 = 6·50 yrs.		+ 7·1	- 63 γ
1909-29-1898-04 = 11·25 yrs.		+ 6·1	- 50 γ

Cape Town. (1, 2, 3, 7)

Date.	Declination.	Dip.	Horizontal Intensity.
1913-97	27° 09'·2 W.	60° 25'·6 S.	·17327
1911-23	27 36·8	1911-26 60 05·9	·17591
1908-82	28 01·0	1908-84 59 48·1	1908-86 ·17773
1905-32		59 18·7	·18121
1904-32		59 14·9	1904-30 ·18186
1903-28			·18293
1902-52	28 47·9	1902-56 58 56·8	
1902-37			·18402
1901-00	28 53·9	1900-98 58 41·0	·18510
1900-19		58 34·8	
1898-30	29 12·6	1898-27 58 20·4	1898-24 ·18684
1897-82	29 03·0	58 11·0	·18795
1895-00	29 18·0	57 52·0	·19000
1890-00	29 36·0	57 15·0	·19160

Secular Variation.

Date.	Declination.	Dip.	Horizontal Intensity.
1913-97-1911-23 = 2·94 yrs.	- 9'·4	+ 6'·7	- 94 γ
1911-23-1908-82 = 2·41 yrs.	- 10'·0	+ 7·4	- 77 γ
1908-86-1905-32 = 3·54 yrs.			- 98 γ
1908-84-1905-32 = 3·52 yrs.		+ 8·3	
1908-82-1902-52 = 6·30 yrs.	- 7·5		
1905-32-1902-56 = 2·76 yrs.		+ 7·9	
1905-32-1903-28 = 2·04 yrs.			- 84 γ
1902-52-1898-06 = 4·46 yrs.	- 4·5	+ 9·1	
1898-06-1890-00 = 8·06 yrs.	- 3·5	+ 7·6	- 53 γ
1913-97-1901-00 = 12·97 yrs.	- 8·1	+ 8·0	- 91 γ

Ceres Road. (2, 3)

Date.	Declination.	Dip.	Horizontal Intensity.
1908·76	27° 38'·0 W.	59° 55'·7 S.	·17873
1900·40	28 45'·1	58 41'·9	·18552
1898·18		58 24'·4	·18722

Secular Variation.

1908·76–1900·40 = 8·36 yrs.	–8'·0	+8'·8	–81 γ
1900·40–1898·18 = 2·22 yrs.		+8·8	–77 γ

Coerney. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1910·97	25° 52'·2 W.	62° 16'·4 S.	·16942
1902·54	27 27'·4	61 22'·4	·17716

Secular Variation.

1910·97–1902·54 = 8·43 yrs.	–11'·6	+6'·4	–92 γ
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Cradock. (2, 3, 7)

Date.	Declination.	Dip.	Horizontal Intensity.
1913·52	24° 29'·8 W.	61° 46'·3 S.	·17107
1908·48	25 39'·6	61 19'·2	·17620
1900·05	26 59'·8	60 23'·7	·18295
1898·28		60 05'·8	·18450

Secular Variation.

1913·52–1908·48 = 5·04 yrs.	–13'·8	+5'·4	–102 γ
1908·48–1900·05 = 8·43 yrs.	–9·5	+6·6	–80 γ
1900·05–1898·28 = 1·77 yrs.		+7·3	–81 γ
1913·52–1900·05 = 13·47 yrs.	–11·2		
1913·52–1898·28 = 15·24 yrs.		+6·6	–88 γ

Dar-es-Salam. (3, 5, 9)

Date.	Declination.	Dip.	Horizontal Intensity.
1909·74	6° 35'·0 W.	37° 19'·8 S.	·28396
1906·67	7 06'·3	37 00'·1	·28651
1905·74	7 12'·8		
1898·70	8 04'·0	36 57'·0	·28974

Secular Variation.

Date.	Declination.	Dip.	Horizontal Intensity.
1909·74–1906·67 = 3·07 yrs.	–10'·2	+6'·4	–83 γ
1909·74–1905·74 = 4·00 yrs.	–9·4		
1905·74–1898·70 = 7·04 yrs.	–7·2		
1909·74–1898·70 = 11·04 yrs.	–8·1	+2·1	–53 γ

East London. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1911·50	24° 57'·1 W.	62° 29'·0 S.	·16867
1902·02	26 45·5	61 36·3	·17736

Secular Variation.

1911·50–1902·02 = 9·48 yrs.	–11'·4	+5'·6	–92 γ
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Eendekuil. (4, 6)

Date.	Declination.	Dip.	Horizontal Intensity.
1913·10	26° 48'·8 W.	60° 00'·1	·17521
1907·02	27 41·2	59 12·9	·18096

Secular Variation.

1913·10–1907·02 = 6·08 yrs.	–8'·6	+7'·9	–94 γ
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Estcourt. (2, 7)

Date.	Declination.	Dip.	Horizontal Intensity.
1913·51	21° 01'·3 W.	61° 07'·5 S.	·17478
1903·77	23 15·7	60 13·9	·18358

Secular Variation.

1913·51–1903·77 = 9·74 yrs.	–13'·8	+5'·5	–90 γ
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Fraserburg Road. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1912·50	26° 00'·5 W.	61° 05'·4 S.	·17384
1902·10		59 48·0	·18370
1897·99		59 14·3	

Secular Variation.

1912·50–1902·10 = 10·4 yrs.		+7'·7	–95 γ
1902·10–1897·99 = 4·11 yrs.		+8·2	

Ginginhloen. (2, 3)

Date.	Declination.	Dip.	Horizontal Intensity.
1908·51	21° 58'·9 W.	61° 27'·6 S.	·17830
1903·83	23 03·2	61 05·3	·18231

Secular Variation.

1908·51–1903·83 = 4·68 yrs.	–13'·7	+4'·8	–85 γ
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Greylingstad. (2, 7)

Date.	Declination.	Dip.	Horizontal Intensity.
1913·52	20° 18'·6 W.	59° 55'·1 S.	·18100
1903·74	22 22·1	58 58·4	·18954

Secular Variation.

1913·52–1903·74 = 9·78 yrs.	–12'·6	+5'·8	–87 γ
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Helwan. (9)

Date.	Declination.	Dip.	Horizontal Intensity.
1910	2° 41'·5 W.	40° 40'·5 N.	·30029
1905	3 12·7	40 36·2	·30159
1903	3 21·4	40 31·2	·30209
1899	3 50·6	1898·9 40 31·9	1899 ·30145

Dip reached a minimum in 1901.

H.I. reached a maximum in 1902.

Secular Variation.

Date.	Declination.	Dip.	Horizontal Intensity.
1910–1905 = 5 yrs.	–6'·2 W.	+0'·9	–26 γ
1905–1899 = 6 yrs.	–6·3	+0·9	–2 γ

Hollerivier. (3, 6)

Date.	Declination.	Dip.	Horizontal Intensity.
1908·94	26° 58'·9 W.	59° 23'·7 S.	·17955
1907·08	27 14·6	59 08·9	·18158

Secular Variation.

1908·94–1907·08 = 1·86 yrs.	–8'·5	+7'·9	–109 γ
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Hutchinson. (2, 3, 4, 7)

Date.	Declination.	Dip.	Horizontal Intensity.
1913·48	25° 10'·9 W.	60° 47'·4 S.	·17393
1911·49	25 34·2	60 31·9	·17596
1908·48	26 05·4	60 09·4	·17920
1904·48	26 39·8	59 40·0	·18231
1900·03	27 15·7	59 06·3	·18615
1899·52		59 03·9	·18624
1898·29		58 52·6	

Secular Variation.

1913·48–1911·49 = 1·99 yrs.	–11'·6	+7'·8	–101 γ
1911·49–1908·48 = 3·01 yrs.	–10·4	+7·5	–108 γ
1908·48–1904·48 = 4·00 yrs.	–8·6	+7·4	–78 γ
1904·48–1900·03 = 4·45 yrs.	–8·0	+7·6	–87 γ
1900·03–1898·29 = 1·74 yrs.		+7·8	
1913·48–1900·03 = 15·45 yrs.	–9·3		
1913·48–1898·29 = 15·19 yrs.		+7·5	
1913·48–1899·52 = 13·96 yrs.			–88 γ

Illovo River. (2, 3, 7)

Date.	Declination.	Dip.	Horizontal Intensity.
1913·51	21° 25'·8	62° 07'·7	·17131
1908·51	22 43·7	61 41·8	·17623
1903·85	23 47·4	61 21·6	·17977

Secular Variation.

1913·51–1908·51 = 5 yrs.	–15'·6	+5'·2	–98 γ
1908·51–1903·85 = 4·66 yrs.	–13·6	+4·3	–76 γ
1913·51–1903·85 = 9·66 yrs.	–14·6	+4·7	–87 γ

Karree. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1911·51	21° 54'·2 W.	60° 10'·2 S.	·17826
1903·43	23 27·9	59 19·0	·18548

Secular Variation.

1911·51–1903·43 = 8·08 yrs.	–11'·5	+6'·3	–89 γ
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Kenhardt. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1913·01	25° 07'·1 W.	59° 21'·8 S.	·18039
1904·96	26 15·4	58 13·2	·18808

Secular Variation.

1913·01–1904·96 = 8·05 yrs.	–8'·5	–8'·5	–96 γ
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Klerksdorp. (2, 4)

Date.	Declination.	Dip.	Horizontal Intensity.
1911·02	22° 16'·3 W.	59° 03'·3 S.	·18520
1903·47	23 42·0	58 12·0	·19124

Secular Variation.

1911·02–1903·47 = 7·55 yrs.	–11'·3	+6'·8	–80 γ
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St. Paul de Loanda. (9)

Date.	Declination.	Dip.	Horizontal Intensity.
1910	16° 12'·3 W.	35° 32'·2 S.	·20125
1908	16 20·4	35 21·7	·20181
1907	16 25·9	35 22·0	·20205
1906	16 30·0	35 15·9	·20196
1905	16 35·4	35 12·0	·20182
1904	16 45·5	35 07·0	·20242
1902	16 59·9	34 52·9	·20297
1899	17 03·0		

T.M., vol. xvi., p. 214
T.M., vol. xii., p. 181

Secular Variation.

Date.	Declination.	Dip.	Horizontal Intensity.
1910–1905 = 5 yrs.	–4'·6	+5'·0	–13 γ
1905–1899 = 6 yrs.	–4'·6		
1899–1888 = 11 yrs.	–6'·0		
1888–1881 = 7 yrs.	–5'·0		

{ From Magnetic Observations in Northern Africa.
By B. F. E. Keeling
(p. 22)

Lorenço Marques. (5, 8)

Date.	Declination.	Dip.	Horizontal Intensity.
1906·53	21° 41'·1 W.	59° 27'·6 S.	·19302
1899·01	23 11·4	58 54·1	·19782